PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: JON E. HOKANSON
SMALL, LARKIN, LLP
10940 WILSHIRE BLVD.
18TH FLOOR
LOS ANGELES, CA 90024

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

Applicant's or agent's file reference 7413-1003	Date of Mailing *(day/month/year)* 09 JAN 2001
International application No. PCT/US00/13937	FOR FURTHER ACTION See paragraphs 1 and 4 below
Applicant WELLE, RICHARD P.	International filing date *(day/month/year)* 19 MAY 2000

1. [X] The applicant is hereby notified that the international search report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the international search report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in rules 90 *bis* 1 and 90 *bis* 3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer HAROLD TUDOR
Facsimile No. (703) 305-3230	Telephone No. (703) 306-4172

Form PCT/ISA/220 (July 1998)*

(See notes on accompanying sheet)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 7413-1003	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
International application No. PCT/US00/13937	International filing date *(day/month/year)* 19 MAY 2000	(Earliest) Priority Date *(day/month/year)* 25 MAY 1999
Applicant WELLE, RICHARD P.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 6 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readable form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [X] **Unity of invention is lacking** (See Box II).

4. With regard to the **title**,

   [ ] the text is approved as submitted by the applicant.

   [X] the text has been established by this Authority to read as follows:

   FRAGMENTED TAGGANT AMMUNITION CODING SYSTEM AND METHOD

5. With regard to the **abstract**,

   [ ] the text is approved as submitted by the applicant.

   [X] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/13937

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1, 2, 15, 16, 59, 60

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

Box III TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)

The technical features mentioned in the abstract do not include a reference sign between parentheses (PCT Rule 8.1(d)).

NEW ABSTRACT

The present invention relates to identification tagging and is specifically directed to identification tagging of ammunition (10). An isotopic taggant (16) is deposited in a layer at the interface between the primer (12) and the propellant so that, as the ammunition is fired, the taggant is dispersed throughout the propellant. The taggant is thus contained in the gunshot residue formed during the firing, and can be read by analysis of residue particules. Alternatively, the taggant may be deposited in a layer (24) under the primer reactants, or in pellets (22) which are easily destroyed by the chemical reactions involved in firing the ammunition, again dispersing the taggant throughout the propellant and the gunshot residue. Non-isotopic chemical taggants may also be employed if they are encoded so as to minimize the possibility of the information being destroyed or improperly read after the taggants ate exposed to the chemical reactions in firing the ammunition. this is accomplished by employing a binary coding system and a system of authentication tags. Particulate taggants may also be used. The required large number of unique identification tags are obtained by using a fragmented coding system wherein each particle encodes only a portion of the serial number.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/13937

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) :F42B 5/02
US CL :102/430
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 102/204, 430;
149/123

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US, 4,222,330 A (KRYSTYNIAK) 16 SEPTEMBER 1980 (16/09/80), SEE ENTIRE DOCUMENT.	1, 2, 15, 16 ----- 59, 60
Y, E	US 6,082,264 A (MEYER ET AL) 04 JULY 2000 (04/07/00), SEE FIG. 5 AND LINES 34-46 OF COL. 6.	59, 60
Y	WO 97/21067 A (BEUKES ET AL) 12 JUNE 1997 (12/06/97), SEE FIG. 2 AND LINES 29-32 OF PAGE 9.	59, 60
A	US 1,650,908 A (RAMSEY) 29 NOVEMBER 1927 (29/11/27)	
A	US 3,772,200 A (LIVESAY) 13 NOVEMBER 1973 (13/11/73)	

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
31 OCTOBER 2000	09 JAN 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer HAROLD TUDOR Telephone No. (703) 306-4172

Form PCT/ISA/210 (second sheet) (July 1998)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/13937

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,018,635 A (RYAN ET AL) 19 APRIL 1977 (19/04/77)	
A	US 4,131,064 A (RYAN ET AL) 26 DECEMBER 1978 (26/12/78)	
A	US 4,329,393 A (LA PERRE ET AL) 11 MAY 1982 (11/05/82)	
A	US 4,359,353 A (KYDD) 16 NOVEMBER 1982 (16/11/82)	
A	US 4,359,399 A (BOYARS) 16 NOVEMBER 1982 (16/11/82)	
A	US 4,363,678 A (NISHIMURA ET AL) 14 DECEMBER 1982	
A	US 4,399,226 A (DANIELSON ET AL) 16 AUGUST 1983 (10/08/83)	
A	US 4,455,179 A (YAMAGUCHI ET AL) 19 JUNE 1984 (19/06/84)	
A	US 5,646,365 A (COLLIER) 08 JULY 1997 (08/07/97)	

International application No.
PCT/US00/13937

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

Group I, tagged ammunition and method of tagging ammunition wherein the taggant is an ingredient of a primer mixture, claims 1, 2, 15, 16, 59 and 60.
Group II, tagged ammunition and method of tagging ammunition wherein the taggant is on a surface of the primer, claims 1, 3-6, 15, 17-20, 59 and 60.
Group III, tagged ammunition and method of tagging ammunition wherein the taggant is in a sapsule, claims 1, 9-11, 15, 25, 26, 59 and 60.
Group IV, tagged ammunition and method of tagging ammunition wherein the taggant is in a pellet, claims 1, 12-14, 15, 27, 28, 59 and 60.
Group V, tagged ammunition and method of tagging ammunition wherein the taggant is on the surface of the primer case, claims 1, 7, 8, 15, 59 and 60.
Group VI, a method of tagging ammunition wherein the taggant is in a layer in a cartridge case, claims 21 and 22.
Group VII, tagged ammunition and method of tagging ammunition wherein the taggant is in a layer in a primer case, claims 1, 15, 23, 24, 59 and 60.
Group VIII, taggant and method of tagging wherein the taggant is a particulate, claims 29-34, and 50-56.
Group IX, taggant and method of tagging wherein the taggant is a chemical, claims 35-37, 42-44, 48-51, 54 and 55.
Group X, taggant and method of tagging wherein the taggant is an isotope, claims 39-41, 45-47, 50-55.
Group XI, method of tagging comtaining a chemical taggant and an isotopic taggant, claim 38.
Group XII, a taggant comprising a particulate taggant and a chemical taggant, claims 56 and 57.
Group XIII, a taggant comprising a particulate taggant and an isotopic taggant, claims 56 and 58.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: JON E. HOKA NSON
SMALL, LARKIN, LLP
10940 WILSHIRE BLVD.
18TH FLOOR
LOS ANGELES, CA 90024

PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of Mailing *(day/month/year)*	29 AUG 2001

Applicant's or agent's file reference	IMPORTANT NOTIFICATION
7413-1003	

International application No.	International filing date *(day/month/year)*	Priority Date *(day/month/year)*
PCT/US00/13937	19 MAY 2000	25 MAY 1999

Applicant
WELLE, RICHARD P.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	HAROLD TUDOR
Facsimile No. (703) 305-3230	Telephone No. (703) 306-4172

Form PCT/IPEA/416 (July 1992)*

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 7413-1003	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US00/13937	International filing date *(day/month/year)* 19 MAY 2000	Priority date *(day/month/year)* 25 MAY 1999
International Patent Classification (IPC) or national classification and IPC IPC(7): F42B 5/02 and US Cl.: 102/430		
Applicant WELLE, RICHARD P.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 0 sheets.

3. This report contains indications relating to the following items:

   I ☒ Basis of the report

   II ☐ Priority

   III ☒ Non-establishment of report with regard to novelty, inventive step or industrial applicability

   IV ☐ Lack of unity of invention

   V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability: citations and explanations supporting such statement

   VI ☐ Certain documents cited

   VII ☐ Certain defects in the international application

   VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
19 MAY 2000	09 JULY 2001
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer HAROLD TUDOR
Facsimile No. (703) 305-3230	Telephone No. (703) 306-4172

Form PCT/IPEA/409 (cover sheet) (July 1998)*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US00/13937

I. Basis of the report

1. With regard to the **elements** of the international application:*

☐ the international application as originally filed

☒ the description:
pages 1-20 , as originally filed
pages NONE , filed with the demand
pages NONE , filed with the letter of _____

☒ the claims:
pages 21-35 , as originally filed
pages NONE , as amended (together with any statement) under Article 19
pages NONE , filed with the demand
pages NONE , filed with the letter of _____

☒ the drawings:
pages 1 , as originally filed
pages NONE , filed with the demand
pages NONE , filed with the letter of _____

☒ the sequence listing part of the description:
pages NONE , as originally filed
pages NONE , filed with the demand
pages NONE , filed with the letter of _____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☒ The amendments have resulted in the cancellation of:

☒ the description, pages NONE

☒ the claims, Nos. NONE

☒ the drawings, sheets/fig NONE

5. ☐ This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

** Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

***Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US00/13937

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non obvious), or to be industrially applicable have not been and will not be examined in respect of:

☐ the entire international application.

☒ claims Nos. 3-14, 17-58

because:

☐ the said international application, or the said claim Nos. _ relate to the following subject matter which does not require international preliminary examination *(specify)*.

☐ the description, claims or drawings *(indicate particular elements below)* or said claims Nos. _ are so unclear that no meaningful opinion could be formed *(specify)*.

☐ the claims, or said claims Nos. _ are so inadequately supported by the description that no meaningful opinion could be formed.

☒ no international search report has been established for said claims Nos. 3-14,17-58 .

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. statement

Novelty (N)	Claims	59, 60	YE
	Claims	1, 2, 15, 16	NO
Inventive Step (IS)	Claims	NONE	YE
	Claims	1, 2, 15, 16, 59, 60	NO
Industrial Applicability (IA)	Claims	1, 2, 15, 16, 59, 60	YE
	Claims	NONE	NO

2. citations and explanations (Rule 70.7)

Claims 1, 2, 15 and 16 lack novelty under PCT Article 33(2) as being clearly anticipated by Krystyniak.

Claims 59 and 60 lack an inventive step under PCT Article 33(3) as being obvious over Krystyniak in view of PCT WO 97/21067. Krystyniak discloses the invention substantially as claimed. However Krystyniak does not disclose using a label on the primer. The PCT application teaches attaching a label to a detonating device to identify the detonating device, see Fig 2 and lines 29-32 of page 9. To employ a label on the primer of the Krystyniak device to identify the primer, as taught by the PCT application, would have been obvious to one having ordinary skill in the art at the time the invention was made.

---------- NEW CITATIONS ----------

NONE

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* 7413-1003

Box No. I TITLE OF INVENTION

FRAGMENTED TAGGANT CODING SYSTEM AND METHOD WITH APPLICATION TO AMMUNITION TAGGING

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

WELLE, RICHARD P.
16351 Grenoble Lane
Huntington Beach, California 92649
US

☑ This person is also inventor.

Telephone No.
310-766-1792

Facsimile No.

Teleprinter No.

State *(that is, country)* of nationality:
US

State *(that is, country)* of residence:
US

This person is applicant for the purposes of: ☑ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:

☐ applicant only

☐ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☑ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

HOKANSON, JON E.
SMALL, THOMAS M.
SMALL LARKIN, LLP
10940 Wilshire Boulevard, 18th Floor
Los Angeles, California 90024
US

Telephone No.
310-209-4499

Facsimile No.
310-209-4450

Teleprinter No.

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*.

Regional Patent

☒ **AP** **ARIPO Patent:** **GH** Ghana, **GM** Gambia, **KE** Kenya, **LS** Lesotho, **MW** Malawi, **SD** Sudan, **SL** Sierra Leone, **SZ** Swaziland, **TZ** United Republic of Tanzania, **UG** Uganda, **ZW** Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT

☒ **EA** **Eurasian Patent:** **AM** Armenia, **AZ** Azerbaijan, **BY** Belarus, **KG** Kyrgyzstan, **KZ** Kazakhstan, **MD** Republic of Moldova, **RU** Russian Federation, **TJ** Tajikistan, **TM** Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☒ **EP** **European Patent:** **AT** Austria, **BE** Belgium, **CH and LI** Switzerland and Liechtenstein, **CY** Cyprus, **DE** Germany, **DK** Denmark, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **IE** Ireland, **IT** Italy, **LU** Luxembourg, **MC** Monaco, **NL** Netherlands, **PT** Portugal, **SE** Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☒ **OA** **OAPI Patent:** **BF** Burkina Faso, **BJ** Benin, **CF** Central African Republic, **CG** Congo, **CI** Côte d'Ivoire, **CM** Cameroon, **GA** Gabon, **GN** Guinea, **GW** Guinea-Bissau, **ML** Mali, **MR** Mauritania, **NE** Niger, **SN** Senegal, **TD** Chad, **TG** Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

☒ **AE** United Arab Emirates
☒ **AL** Albania .....
☒ **AM** Armenia .....
☒ **AT** Austria .....
☒ **AU** Australia .....
☒ **AZ** Azerbaijan
☒ **BA** Bosnia and Herzegovina .....
☒ **BB** Barbados
☒ **BG** Bulgaria .....
☒ **BR** Brazil .....
☒ **BY** Belarus .....
☒ **CA** Canada
☒ **CH and LI** Switzerland and Liechtenstein
☒ **CN** China .....
☒ **CR** Costa Rica .....
☒ **CU** Cuba .....
☒ **CZ** Czech Republic .....
☒ **DE** Germany .....
☒ **DK** Denmark .....
☒ **DM** Dominica
☒ **EE** Estonia .....
☒ **ES** Spain .....
☒ **FI** Finland .....
☒ **GB** United Kingdom
☒ **GD** Grenada
☒ **GE** Georgia .....
☒ **GH** Ghana .....
☒ **GM** Gambia
☒ **HR** Croatia .....
☒ **HU** Hungary .....
☒ **ID** Indonesia
☒ **IL** Israel .....
☒ **IN** India .....
☒ **IS** Iceland
☒ **JP** Japan .....
☒ **KE** Kenya .....
☒ **KG** Kyrgyzstan .....
☒ **KP** Democratic People's Republic of Korea .....
☒ **KR** Republic of Korea .....
☒ **KZ** Kazakhstan .....
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Check-boxes reserved for designating States which have become party to the PCT after issuance of this sheet:

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Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn bythe applicant at the expiration of that time limit. *(Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)*

Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1) 25.05.99	60/135,866	US		
item (2)				
item (3)				

☑ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s):

* *Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one county party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used)*: ISA / USPTO

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority)*: Date *(day/month/year)* Number Country *(or regional Office)*

Box No. VIII CHECK LIST; LANGUAGE OF FILING

This international application contains the following **number of sheets**:

request	3
description (excluding sequence listing part)	20
claims	15
abstract	1
drawings	1
sequence listing part of description	0
Total number of sheets	40

This international application is **accompanied by** the item(s) marked below:

1. ☑ fee calculation sheet
2. ☑ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No. VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☐ other *(specify)*:

Figure of the drawings which should accompany the abstract: 1

Language of filing of the international application: ENGLISH

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

M. P. Welle

RICHARD P. WELLE,
APPLICANT AND INVENTOR

19 MAY 2000
DATE

For receiving Office use only

1. Date of actual receipt of the purported international application:
2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority (if two or more are competent): ISA /
6. ☐ Transmittal of search copy delayed until search fee is paid.

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The demand must be filed directly with the competent International Preliminary Examining Authority or, if two or more Authorities are competent, with the one chosen by the applicant. The full name or two-letter code of that Authority may be indicated by the applicant on the line below:

IPEA/ US

PCT

CHAPTER II

DEMAND

under Article 31 of the Patent Cooperation Treaty:
The undersigned requests that the international application specified below be the subject of international preliminary examination according to the Patent Cooperation Treaty and hereby elects all eligible States (except where otherwise indicated).

For International Preliminary Examining Authority use only

Identification of IPEA	Date of receipt of DEMAND

Box No. I IDENTIFICATION OF THE INTERNATIONAL APPLICATION		Applicant's or agent's file reference 7413-1003
International application No.	International filing date *(day/month/year)*	(Earliest) Priority date *(day/month/year)*

Title of invention

FRAGMENTED TAGGANT CODING SYSTEM AND METHOD WITH APPLICATION TO AMMUNITION TAGGING

Box No. II APPLICANT(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*	Telephone No.: 310-766-1792
RICHARD P. WELLE 16351 Grenoble Lane Huntington Beach, California 92649 US	Facsimile No.:
	Teleprinter No.:

State *(that is, country)* of nationality:	State *(that is, country)* of residence:
US	US

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code andname of country.)*

State *(that is, country)* of nationality:	State *(that is, country)* of residence:

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code andname of country.)*

State *(that is, country)* of nationality:	State *(that is, country)* of residence:

☐ Further applicants are indicated on a continuation sheet.

International application No.

Box No. III AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The following person is ☑ agent ☐ common representative

and ☐ has been appointed earlier and represents the applicant(s) also for international preliminary examination.

☑ is hereby appointed and any earlier appointment of (an) agent(s)/common representative is hereby revoked.

☐ is hereby appointed, specifically for the procedure before the International Preliminary Examining Authority, in addition to the agent(s)/common representative appointed earlier.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

HOKANSON, JON E.
SMALL, THOMAS M.
SMALL LARKIN, LLP
10940 Wilshire Boulevard, 18th Floor
Los Angeles, California 90024
US

Telephone No.: 310-209-4499

Facsimile No.: 310-209-4450

Teleprinter No.:

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special addr ess to which correspondence should be sent.

Box No. IV BASIS FOR INTERNATIONAL PRELIMINARY EXAMINATION

Statement concerning amendments:*

1. The applicant wishes the international preliminary examination **to start on the basis of:**

☐ the international application as originally filed

the description ☐ as originally filed
☐ as amended under Article 34

the claims ☐ as originally filed
☐ as amended under Article 19 (together with any accompanying statement)
☐ as amended under Article 34

the drawings ☐ as originally filed
☐ as amended under Article 34

2. ☐ The applicant wishes any amendment to the claims under Article 19 to be considered as reversed.

3. ☑ The applicant wishes the start of the international preliminary examination **to be postponed** until the expiration of 20 months from the priority date unless the International Preliminary Examining Authority receives a copy of any amendments made under Article 19 or a notice from the applicant that he does not wish to make such amendments (Rule 69.1(d)). *(This check-box may be marked only where the time limit under Article 19 has not yet expired.)*

* Where no check-box is marked, international preliminary examination will start on the basis of the international application as originally filed or, where a copy of amendments to the claims under Article 19 and/or amendments of the international application under Article 34 are received by the International Preliminary Examining Authority before it has begun to draw up a written opinion or the international preliminary examination report, as so amended.

Language for the purposes of international preliminary examination: .....

☑ which is the language in which the international application was filed.

☐ which is the language of a translation furnished for the purposes of international search.

☐ which is the language of publication of the international application.

☐ which is the language of the translation (to be) furnished for the purposes of international preliminary examination.

Box No. V ELECTION OF STATES

The applicant hereby **elects all eligible States** *(that is, all States which have been designated and which are bound by Chapter II of the PCT)*

excluding the following States which the applicant wishes **not to elect:**

Sheet No. 3

International application No.

Box No. VI CHECK LIST

The demand is accompanied by the following elements, in the language referred to in Box No. IV, for the purposes of international preliminary examination:			For International Preliminary Examining Authority use only: received	not received
1. translation of international application	:	sheets	☐	☐
2. amendments under Article 34	:	sheets	☐	☐
3. copy (or, where required, translation) of amendments under Article 19	:	sheets	☐	☐
4. copy (or, where required, translation) of statement under Article 19	:	sheets	☐	☐
5. letter	:	sheets	☐	☐
6. other *(specify)*	:	sheets	☐	☐

The demand is also accompanied by the item(s) marked below:

1. ☑ fee calculation sheet
2. ☑ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ nucleotide and or amino acid sequence listing in computer readable form
6. ☐ other *(specify)*:

Box No. VII SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the demand).

JON E. HOKANSON, AGENT

19 MAY 2000
DATE

For International Preliminary Examining Authority use only

1. Date of actual receipt of DEMAND:
2. Adjusted date of receipt of demand due to CORRECTIONS under Rule 60.1(b):
3. ☐ The date of receipt of the demand is AFTER the expiration of 19 months from the priority date and item 4 or 5, below, does not apply. ☐ The applicant has been informed accordingly.
4. ☐ The date of receipt of the demand is WITHIN the period of 19 months from the priority date as extended by virtue of Rule 80.5.
5. ☐ Although the date of receipt of the demand is after the expiration of 19 months from the priority date, the delay in arrival is EXCUSED pursuant to Rule 82.

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Demand received from IPEA on:

PCT

POWER OF ATTORNEY

(for an international application filed under the Patent Cooperation Treaty)

(PCT Rule 90.4)

The undersigned applicant(s) *(Names should be indicated as they appear in the request)*:

RICHARD P. WELLE
16351 Grenoble Lane
Huntington Beach, California 92649
US

hereby appoints (appoint) the following person as: ☑ agent ☐ common representative

Name and address
(Family name followed by given name; for a legal entity, full official designat ion. The address must include postal code and name of country.)

HOKANSON, JON E.
SMALL, THOMAS M.
SMALL LARKIN, LLP
10940 Wilshire Boulevard, 18th Floor
Los Angeles, California 90024
United States of America

to represent the undersigned before

☑ all the competent International Authorities
☐ the International Searching Authority only
☐ the International Preliminary Examining Authority only

in connection with the international application identified below:

Title of the invention: FRAGMENTED TAGGANT CODING SYSTEM AND METHOD WITH APPLICATION TO AMMUNITION TAGGING

Applicant's or agent's file reference: 7413-1003

International application number (if already available):

filed with the following Office United States of America (US) as receiving Office
and to make or receive payments on behalf of the undersigned.

Signature of the applicant(s) *(where there are several applicants, each of them must sign; next to each sign ature, indicate the name of the person signing and the capacity in which the person signs, if such capacity is not obvious fr om reading the request or this power):*

R P Welle

RICHARD P. WELLE
APPLICANT AND INVENTOR

Date: 19 MAY 2000

Form PCT/Model of power of attorney (for a given international application)(Jul y 1992)

CHAPTER II

PCT

FEE CALCULATION SHEET

Annex to the Demand for international preliminary examination

International application No.	For International Preliminary Examining Authority use only
Applicant's or agent's file reference 7413-1003	Date stamp of the IPEA
Applicant: RICHARD P. WELLE	

Calculation of prescribed fees

1. Preliminary examination fee	490.00	P
2. Handling fee *(Applicants from certain States are entitled to a reduction of 75% of the handling fee. Where the applicant is (or all applicants are) so entitled, the amount to be entered at H is 25% of the handling fee.)*	153.00	H
3. Total of prescribed fees Add the amounts entered at P and H and enter total in the TOTAL box	643.00	TOTAL

Mode of Payment

☑	authorization to charge deposit account with the IPEA (see below)	☐	cash
☑	cheque	☐	revenue stamps
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Deposit Account Authorization *(this mode of payment may not be available at all IPEAs)*

The IPEA/ US ☑ is hereby authorized to charge the total fees indicated above to my deposit account.

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19-2500	19 MAY 2000	
Deposit Account Number	Date *(day/month/year)*	Signature

See Notes to the fee calculation sheet

This sheet is not part of and does not count as a sheet of the international application.

PCT

FEE CALCULATION SHEET
Annex to the Request

For receiving Office use only

International application No.

Date stamp of the receiving Office

Applicant's or agent's file reference 7413-1003

Applicant
RICHARD P. WELLE

CALCULATION OF PRESCRIBED FEES

1. TRANSMITTAL FEE . . . . . 240.00 T

2. SEARCH FEE . . . . . 700.00 S

International search to be carried out by USPTO

(If two or more International Searching Authorities are competent in relation to the international application, indicate the name of the Authority which is chosen to carry out the international search.)

3. INTERNATIONAL FEE

Basic Fee

The international application contains 47 sheets.

first 30 sheets 427.00 b1

17 (remaining sheets) x 10.00 (additional amount) = 170.00 b2

Add amounts entered at b1 and b2 and enter total at B . . . . 597.00 B

Designation Fees

The international application contains all designations.

8 (number of designation fees payable *(maximum 8)*) x 92.00 (amount of designation fee) = 736.00 D

Add amounts entered at B and D and enter total at I . . . . . 1333.00 I

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4. FEE FOR PRIORITY DOCUMENT *(if applicable)* . . . . . 15.00 P

5. TOTAL FEES PAYABLE . . . . . 2288.00 TOTAL

Add amounts entered at T, S, I and P, and enter total in the TOTAL box

☐ The designation fees are not paid at this time.

MODE OF PAYMENT

☑ authorization to charge deposit account (see below)	☐ bank draft	☐ coupons
☑ cheque	☐ cash	☐ other *(specify)*:
☐ postal money order	☐ revenue stamps	

DEPOSIT ACCOUNT AUTHORIZATION *(this mode of payment may not be available at all receiving Offices)*

The RO/ US

☑ is hereby authorized to charge the total fees indicated above to my deposit account.

☑ *(this check-box may be marked only if the conditions for deposit accounts of the receiving Office so permit)* is hereby authorized to charge any deficiency or credit any overpayment in the total fees indicated above to my deposit account.

☐ is hereby authorized to charge the fee for preparation and transmittal of the priority document to the International Bureau of WIPO to my deposit account.

19-2500	19 May 2000	
Deposit Account No.	Date *(day/month/year)*	Signature

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

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30 November 2000 (30.11.2000)

PCT

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(74) Agents: HOKANSON, Jon, E. et al.; Small Larkin, LLP, 18th Floor, 10940 Wilshire Boulevard, Los Angeles, CA 90024 (US).

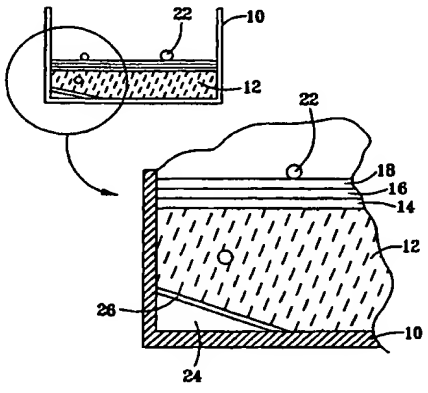
(81) Designated States *(national)*: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *Without international search report and to be republished upon receipt of that report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: FRAGMENTED TAGGANT CODING SYSTEM AND METHOD WITH APPLICATION TO AMMUNITION TAGGING



(57) Abstract: The present invention relates to identification tagging, and is specifically directed to identification tagging of ammunition. An isotopic taggant is deposited in a layer at the interface between the primer and the propellant so that, as the ammunition is fired, the taggant is dispersed throughout the propellant. The taggant is thus contained in the gunshot residue formed during the firing, and can be read by analysis of residue particles. Alternatively, the taggant may be deposited in a layer under the primer reactants, or in pellets which are easily destroyed by the chemical reactions involved in firing the ammunition, again dispersing the taggant throughout the propellant and the gunshot residue. Non-isotopic chemical taggants may also be employed if they are encoded so as to minimize the possibility of the information being destroyed or improperly read after the taggants are exposed to the chemical reactions in firing the ammunition. This is accomplished by employing a binary coding system and a system of authentication tags. Particulate taggants may also be used. The required large number of unique identification tags are obtained by using a fragmented coding system wherein each particle encodes only a portion of the serial number.

WO 00/71966 A2

FRAGMENTED TAGGANT CODING SYSTEM AND METHOD WITH APPLICATION TO AMMUNITION TAGGING

Technical Field

The present invention relates to the field of identification taggants. More specifically, the present invention relates to the identification tagging of ammunition, such as small arms ammunition.

Background Art

A number of systems have been proposed for use as identification taggants, with an extensive body of work investigating methods for tagging explosives.

With respect to ammunition, a system has been proposed and tested wherein the addition of rare-earth elements to ammunition enhanced the delectability of gunshot residue by giving it an unambiguous composition due to incorporation of elements which are easily detected by neutron activation (Bryan et al., 1966). This method was only intended to provide a positive indication of the presence of gunshot residue. It was neither capable of encoding a usefully large number of identification codes, nor was any attempt made to encode any identification information in the taggants.

Disclosure of Invention

It is an object of this invention to provide a system of and a method for coding taggants which will facilitate economic generation of a very large number of unique identifying codes.

The method employs a fragmented coding scheme where a code is comprised of several individual components which are not physically connected to one another.

It is further an object of this invention to provide a system of and a method for coding taggants which will minimize the probability of false code readings in chemically reacting or contaminated systems. The method employs a binary or related coding system wherein the value of each bit of the code is indicated by the presence of one component, and the absence of the other component, of a designated pair of chemicals. The method further employs an authentication code system.

It is further an object of this invention to provide a system of and a method for tagging ammunition which will minimize concerns about taggant effects on safety and reliability of the tagged ammunition. The method employs a taggant embedded in a thin layer between the primer and propellant in an ammunition round. The method further employs additional layers of material isolating the taggant layer from the primer and the propellant.

Brief Description Of The Drawings

Other objects and advantages of the invention will become apparent from the foregoing detailed description taken in connection with the accompanying drawings, in which

Figure 1 is a partial cross-sectional view of a primer adapted for use with preferred embodiments of the present invention.

Figure 2 is a partial cross-sectional view of a cartridge case and projectile adapted for use with preferred embodiments of the present invention.

Best Mode for Carrying Out the Invention

Known taggant systems and methods fall into three categories. These include: (1) survivable distributed systems and methods; (2) semi-survivable distributed systems and methods; and (3) particulate systems and methods.

Distributed Systems

Distributed systems encode the taggant information in substances which are distributed through one or more components of the ammunition. These taggants encode information either in the presence or absence of certain chemical substances, or in the relative concentration of certain chemical substances. In distributed systems, the tagging chemicals are directly mixed with other components of the ammunition, and may be exposed to the chemical reactions involved in firing the ammunition. This leads to the further subdivision of the distributed category into the survivable and semi-survivable sub-categories. The survivable systems are those in which the taggant information is encoded in substances which, preferably, will not be altered in any way by chemical reactions. The semi-survivable systems include chemicals which may be affected by the chemical reactions, but for which, preferably, the taggant information has a high probability of surviving the reactions.

Of the known systems, only radioactive tracer and isotope ratio systems can be classed as survivable distributed systems. Both of these systems encode information in the isotopic composition of single elements. The chemical reactions involved in firing ammunition will have no significant effect on isotopic compositions. As long as enough atoms can be recovered to determine the isotopic composition of the relevant elements, the taggant information can be read.

The semi-survivable systems include chemical tracer and isotopic substitution systems. The chemical tracer system, using rare-earth elements, is considered semi-survivable because the taggant information is encoded in the relative concentration of different elements. Although these ratios are likely to be little affected by the chemical reactions involved in firing ammunition, it cannot be said with certainty that the effect will be negligible. This decreases the degree of reliability of the tagging information obtained by analyzing the residue of expended ammunition tagged with this system. The isotopic substitution system is considered semi-survivable because the chemicals containing the isotopes may be destroyed in the chemical reactions of the ammunition. Although the isotopes themselves cannot be destroyed, the information is encoded in the presence of the isotopes in the substituted chemicals. If the chemicals are destroyed, the taggant information is lost. If the taggant information is encoded in the relative concentration of different substituted chemical compounds, then the taggant information could become corrupted by selective destruction of one of the substituted compounds. In one alternative system information is encoded in the presence or absence of each of a number of chemical elements, isotopes, or compounds in a pre-defined set. This gives improved reliability over the concentration method, but there is still some uncertainty in that some chemical compounds which are initially present in the taggant could be destroyed in firing the ammunition. In the subsequent analysis, it would not be possible to determine whether the absence of a particular compound was the result of its initial absence, or its destruction in the firing. This could lead to incorrect reading of the taggant information.

An improved coding scheme has been devised which will provide an indication when tagging chemicals are destroyed. In such a case, the analysis will lead to information which is ambiguous rather than erroneous. The method works by using a binary coding scheme where each bit in the binary code is represented by two chemicals, identified for illustration purposes

as chemical A and chemical B. In a representative system the presence of chemical A would indicate a bit value of 0, while the presence of chemical B would indicate a bit value of 1. In analyzing a sample, four outcomes are possible. (1) The presence of only chemical A would indicate a bit value of 0. (2) The presence of only chemical B would indicate a bit value of 1. (3) The absence of both chemicals would indicate that the tagging chemical, and therefore the taggant information, had been destroyed. (4) The presence of both chemicals would indicate that the system had been contaminated, and that therefore the tagging information had been destroyed.

Thus, under most circumstances, the analysis will either give the correct result, or indicate that the information had been destroyed. An incorrect result is possible only in a case where the correct tagging chemical had been destroyed, and the system had been contaminated with the incorrect tagging chemical.

With only two chemicals, one can tag no more than two separate batches of ammunition. A useful system must be able to provide unique identifying information for far more than two batches, and must be able to encode identifying information corresponding to any type of alphanumeric or other identifier. Most commonly, such an identifier would be a serial number composed of arabic numerals, although other identification systems are possible. The term "serial number" is used hereinafter to encompass all types of symbolic identifiers. By combining multiple pairs of chemicals to build up a binary serial number, an arbitrarily large number of batches can be tagged. For example, to identify one million separate batches would require a binary serial number 20 bits long (2^{20} = 1,048,576). Tagging these batches using this system would require 40 distinct chemicals, with each of 20 pairs being used to identify the value of one bit in the serial number. If, in analyzing a sample from one of these batches of ammunition, only 19 of the expected 20 chemicals are found, then one bit of the serial number is lost. However, this still narrows the serial number from one million possibilities to only two.

While the system is simple with a binary coding scheme i.e., using base-2 numbers, there may be benefits to using other bases. For example, triplets of chemicals could be used to encode a base-3 serial number. In this system, the presence of chemical A, B, or C would indicate a value of 0, 1, or 2 for one trit (base-3 digit) in the serial number. The absence of all three of these chemicals would indicate a loss of information, and the presence of two or more of the chemicals would indicate contamination. Using this system, one million batches of ammunition could be tagged with 39 chemicals in 13 triplets ($3^{13} = 1,594,323$). Other bases could also be used, but as the base number gets larger, a point is reached where more rather than fewer tagging chemicals are required. A base-10 system for example, would require 60 chemicals to tag one million batches. The coding system described here could be implemented using ordinary chemical compounds, using compounds in which one or more atoms are substituted with rare isotopes, or using isotopes themselves.

While these improvements will make a semi-survivable distributed system more reliable, survivable systems may be preferable.

One survivable distributed tagging system of the present invention employs only stable isotopes. In this system, unique taggants, each corresponding to a unique identification code, are created by mixing unique combinations of ratios of multiple stable isotopes of one or more elements. The resulting mixture is added to the substance or product to be tagged. When identification is required, the isotope abundance ratios of the taggant element or elements are measured, and the resultant measurements are compared with the appropriate identification tagging records made at the time the substance was tagged.

A code based on an abundance ratio of multiple isotopes of a single element presents two distinct advantages over systems using abundance ratios of elements or compounds. First, the isotopic abundance ratios can be more precisely measured than abundance ratios of

elements or compounds. Second, the isotopic abundance ratio will not be modified by non-nuclear physical or chemical processes except those specifically designed for isotope separation, so the taggant code will not be destroyed by chemical reactions or explosions.

Elements which could be used for this technique include any element with more than one stable isotope. Of the 83 non-radioactive elements known to exist on earth, 62 have more than one stable isotope, and 40 have more than two stable isotopes. The element tin (Sn) has the largest number (10) of stable isotopes for any single element. The following table lists the symbol of each element under the number of stable isotopes for each of the naturally occurring stable elements.

Table I

Elements grouped according to their number of stable isotopes

1	2	3	4	5	6	7	8	9	10
Be	H	O	S	Ti	Ca	Mo	Cd	Xe	Sn
F	He	Ne	Cr	Ni	Se	Ru	Te		
Na	Li	Mg	Fe	Zn	Kr	Ba			
Al	B	Si	Sr	Ge	Pd	Nd			
P	C	Ar	Ce	Zr	Er	Sm			
Sc	N	K	Pb	W	Hf	Gd			
Mn	Cl	U			Pt	Dy			
Co	V					Yb			
As	Cu					Os			
Y	Ga					Hg			
Nb	Br								
Rh	Rb								
I	Ag								
Cs	In								
Pr	Sb								
Tb	La								
Ho	Eu								
Tm	Lu								
Au	Ta								
Bi	Re								
Th	Ir								
	Tl								

Among the 40 elements having more than two stable isotopes, there are a total of 222 stable isotopes. These totals include some isotopes which are slightly radioactive, but which have very long half lives and are present in naturally occurring samples of the elements. In most cases, the relative concentrations of the stable isotopes found in any given element anywhere on earth are constant to within one part in fifty thousand. The ratios are easily and precisely measured by various known techniques. Highly enriched samples of most stable isotopes are available commercially.

In this system, the abundance ratio of two or more isotopes in each of one or more elements in a substance is artificially controlled to provide for subsequent identification of the substance. For example, for labeling, or tagging, ten commercially prepared batches of ammunition, the element europium (Eu) can be used. It has two stable isotopes with atomic masses of 151 and 153. In natural europium, these two isotopes are present in the concentrations 47.77%, and 52.23% respectively. A code can be created for these batches by preparing a series of isotopic samples containing ^{151}Eu and ^{153}Eu in a patterned series of ten concentration ratios such as 5/95, 15/85, 25/75, 35/65, 45/55, 55/45, 65/35, 75/25, 85/15, and 95/5, with each ratio assigned to one specific batch. These samples can be prepared either with elemental europium, or with europium as an element in a compound such as Eu_2O_3. A small quantity of one of these samples can be added, by any of a number of means, to each batch of ammunition to be tagged, according to the following table.

Table II

Batch	$^{151}Eu/^{153}Eu$ (Abundance Ratio)
0	5/95
1	15/85
2	25/75
3	35/65
4	45/55
5	55/45
6	65/35
7	75/25
8	85/15
9	95/5

Subsequent measurement of the concentration ratio of ^{151}Eu to ^{153}Eu in the ammunition, or in the residue left after it is fired, would yield a ratio identifying the batch in which the ammunition was manufactured. In this example, the ten unique values of the concentration ratio can distinguish each of the ten batches of ammunition.

A significant increase in the number of possible unique codes is achieved by using more than one pair of stable isotopes in creating the code. Continuing the above example, the code can be expanded by adding to the ammunition an additional element (e.g. neodymium, Nd) with its own specific concentration ratio of isotopes (e.g. ^{143}Nd and ^{146}Nd). The code can be further expanded by adding a third element with its specific isotope concentration ratio (e.g. dysprosium, ^{161}Dy and ^{164}Dy).

The following table illustrates how a system using these three pairs of isotopes can be used to create an identification code (e.g. a three digit serial number). The first column lists the serial number, the remaining columns list the abundance ratios of each of the europium

isotopes ^{151}Eu and ^{153}Eu; the neodymium isotopes ^{143}Nd and ^{146}Nd; and the dysprosium isotopes ^{161}Dy and ^{163}Dy, respectively.

Table III

Isotope Abundance Ratios

Serial Number	$^{151}Eu/^{153}Eu$	$^{143}Nd/^{146}Nd$	$^{161}Dy/^{163}Dy$
000	5/95	5/95	5/95
001	5/95	5/95	15/85
002	5/95	5/95	25/75
....	....	....	....
009	5/95	5/95	95/9
010	5/95	15/85	5/95
011	5/95	15/85	15/85
....	....	....	....
099	5/95	95/5	95/5
100	15/85	5/95	5/95
101	15/85	5/95	15/85
....	....	....	....
998	95/5	95/5	85/15
999	95/5	95/5	95/5

By reference to this table, measurement of the three abundance ratios $^{151}Eu/^{153}Eu$, $^{143}Nd/^{146}Nd$, and $^{161}Dy/^{163}Dy$ in a tagged substance will allow determination of the identification code (e.g. the serial number) of the substance. In this table, not all possible entries are shown. Using the coding scheme of Table III, a total of 10^3 or 1000 unique serial numbers can be created. Additional pairs of isotopes could be used to provide additional digits, thereby increasing the number of available serial numbers. Following the same pattern, a system using N pairs of isotopes to create serial numbers results in 10^N unique serial numbers.

The example illustrated in Table III utilized 10% variations in the concentration ratios of each of the isotope pairs. In fact, smaller variations in the isotopic concentration ratios can be used and measured with sufficient accuracy to be useful in the present invention. When two pairs of isotopes are each controlled and measured to within 1% and combined in a single code, there are 100^2 or ten thousand (10,000) unique codes available. Three pairs of isotopes at 1% precision would provide for 100^3 or one million (1,000,000) unique codes. By extension, N pairs of isotopes, each controlled and measured to within 1% and combined in a single code, would produce 100^N unique codes. This system will allow simple and economic generation of a very large number of unique codes, such as would be useful for ammunition tagging.

Particulate Systems

The particulate category comprises those systems where the taggant information is encoded in small particles which are designed to survive the firing of the ammunition. An example in this category is the color coded plastic beads currently used for tagging explosives in Switzerland. Alternative identifying means also have been proposed for coding the particles, including particle shape, chemical composition, or even microscopic writing. Two principal issues arise when considering application of particulate taggants to ammunition. (1) If the particles are substantially destroyed in the firing of the ammunition, the taggant signal will be degraded or lost. For this reason, the particles are intentionally designed to be robust. This may lead to concerns about their potential effects on firearm mechanisms. (2) The particles are typically manufactured at a remote site, and in large batches, with every particle in a given batch having the same code. Under systems proposed to date, generating one million unique taggant codes would require fabricating one million batches of particles. In the current state of the art,

no practical method is available for generating very large numbers of small batches of uniquely identical particles, and for integrating these into an ammunition manufacturing process.

A solution to the second problem is to use a fragmented coding system in which each particle encodes only a portion of a serial number. How this system would reduce the required number of distinct batches of particles is best illustrated by example. Suppose it is desired to have a given factory produce a run comprising a series of one million ammunition batches, each with its own serial number. If each taggant particle encodes an entire serial number, this would require one million unique batches of particles. Using a fragmented coding system, the same one million batches could be tagged with 301 batches of taggant particles as follows. The first batch of particles (called the master batch) would contain identifying information about the factory and the run, and could be encoded using any of a number of identifying means as described above. The remaining 300 batches of particles would consist of particles coded with a three element coding system, such as a three-band color code. These batches of particles would be divided equally into three groups; A, B, and C. The one hundred particle batches in group A would consist of particles where the first band is always one color, say blue. The remaining two bands would use a 10 color code to indicate the value of two digits of a digital serial number. The one hundred particle batches in groups B and C would similarly have a first band identifying the group, say yellow and red respectively. The remaining two bands would encode two digits of a digital serial number in the same manner as group A. Each batch of ammunition could then be uniquely identified by introducing particles from the master batch, and from one batch from each of groups A, B, and C. Assume that the 10-color encoding scheme follows the example of the electronics industry and used black, brown, red, orange, yellow, green, blue, violet, gray, and white to represent the digits 0 through 9 respectively. Then ammunition batch number 576,039, for example, would be tagged with the master particles, and with three additional particle

batches. The first of these would have blue, green, and violet bands, with the green and violet representing 5 and 7 respectively, and the blue indicating that they encode the first two digits of the serial number. The second batch of particles would have yellow, blue, and black bands, and the third would have red, orange, and white bands. If a sample of residue from the ammunition in this batch is found, the taggant code could be read by finding a particle from each of the four particle batches. The numbers used here were picked for example purposes only. A similar method could be used employing six particle groups, each encoding only one digit of a digital serial number. This would require only 61 batches of particles for one million serial numbers. It is also possible to employ non-digital serial numbers. For example, an 8-color code could be used to encode base-8 serial numbers. Likewise, a 12-color code could be used to encode base-12 serial numbers. Identifying means other than color coding could also be used to encode the serial number components on the particles, or to identify which digits of the serial number are being encoded.

The key to reducing the total number of unique batches of particles, and thereby improve manufacturability, is the use of multiple batches of particles to encode a serial number piece by piece. An assembly line would then only need to control the injection of particles from selected batches to build up a large number of serial numbers from a relatively small number of distinct batches of particles. While very useful for ammunition, where identification of large numbers of separate batches would be useful for law enforcement purposes, the method proposed here has more general utility for any field of manufacture where there exists a need to separately identify a large number of discrete units of production. Examples include, but are not limited to, paint, crude oil, fuel oil, hazardous waste, paper, ink, drugs, raw materials used in the manufacture of drugs, chemicals, compact disks, laser disks, computer disks, video tapes, audio tapes, electronic

circuits, explosives, currency, clothing, computers, electronic components, and automotive components.

Particulate tagging systems can also be combined advantageously with isotopic or chemical tagging systems. One disadvantage of the isotope ratio and chemical tagging systems is that it is not obvious whether or not a taggant is present in a given sample. Without resorting to a sophisticated chemical analysis, a tagged sample will appear identical to an untagged sample. A solution to this difficulty is to combine the isotopic taggant system with another system using particulates that are visible with the unaided eye, or with a simple magnifying glass or microscope. The primary purpose of the particulate taggant would be to indicate the presence of the isotopic or chemical taggant. The particulate taggant may also encode some information, such as the identity of the manufacturer, type of ammunition, date of manufacture, or place of manufacture, but because of its greater versatility, the isotopic or chemical taggant would carry most or all of the identifying information.

For any tagging system, there can be a concern about tags which have been counterfeited, altered, or contaminated by other tags. For example, if two rounds of ammunition were produced with powder tagged using the isotope ratio technique, then combining the powder from those two rounds would produce isotope ratios that would match neither of the initial tags. Subsequent reading of the isotope ratio in the powder would not identify either of the initial two batches, but could incorrectly identify a third unrelated batch as the source of the tag.

A way to avoid this problem is to use one or more additional pairs or multiples of isotopes to create an authentication code. Each taggant value would have a corresponding authentication code. If a taggant code is accidently created by combining two other codes, or through some other contamination process, it is unlikely that the correct authentication code would also be created. The degree of improbability is determined by the number of unique

authentication codes. The following simplified example illustrates the technique. Assume that there are two batches of powder tagged using the isotope ratio system at 10% resolution. The first one is tagged with europium using the isotopes ^{151}Eu and ^{153}Eu in the ratio 25/75. This batch also contains an authentication code in the form of neodymium, with the isotopes ^{143}Nd and ^{146}Nd in the ratio 45/55. The second batch of powder is also tagged with europium, using the isotopes ^{151}Eu and ^{153}Eu in the ratio 45/55. This batch also contains an authentication code in the form of neodymium, with the isotopes ^{143}Nd and ^{146}Nd in the ratio 5/95. If these two batches were mixed in equal amounts, the taggant code of the europium in the combined batch would be read as 35/65, and the authentication code of the neodymium would be read as 25/75. As the taggants were using 10% variations in concentration ratios in forming the code, there is only one chance in 10 that this would be the correct authentication code. By using higher precisions, such as 1% resolution in forming the isotope ratio codes, and additional pairs or multiples of isotopes, the probability of accidently producing a correct authentication code can be made arbitrarily small. Similar authentication coding schemes can be used for particulate and chemical taggants. It may also be advantageous to create an authentication tag using a different system altogether than the identification tag. For example, a fragmented particulate identification taggant could be combined with an isotopic authentication taggant. Other combinations are also possible.

Methods of Application

Regardless of what type of taggant is used, the taggant must be applied to the ammunition so as to acceptably balance user concerns about possible effects on safety and performance, and the utility of the taggant. The most useful taggant will be one that can be read from the smallest sample of projectile, projectile fragment, or gunshot residue collected from a crime scene.

Gunshot residue typically consists of two types of particles. The first is recondensed projectile material which was vaporized by frictional heating of the projectile as it passed through the barrel of the firearm. The second type of particle is composed of the solid residue left behind by the reaction of the primer and propellant charges. Typically, the primer produces the majority of this material. Because most recovered projectiles and projectile fragments will be coated with detectable gunshot residue, a taggant which is uniformly dispersed in the gunshot residue will be of maximum utility. Ideally, it should be present at a concentration high enough to be read from a single residue particle.

An obvious way to maximize uniform distribution of the taggant in the residue would be to distribute it uniformly in the propellant charge (typically gunpowder). This method was used in most of the ammunition taggant tests conducted to date. Unfortunately, this method has the drawback that the taggant is in direct contact with the propellant, leading to concerns about sensitizing the propellant for premature ignition.

An alternative would be to blend the taggant with the primer reactants. The firing of the ammunition results in mixing of the primer reaction products with the propellant, thereby igniting the propellant. If the taggant is carried in the primer reaction products, it will be blended with the propellant as it is ignited, and will then be distributed throughout the gunshot residue. This method has the advantage that the taggant is not exposed to the propellant before the propellant is ignited. The concern about sensitizing the propellant is removed. However, in this method, the concern is transferred to the primer, which may be even more sensitive to the taggant than is the powder.

In an ideal case, the taggant would not be mixed with either the primer or propellant prior to firing the ammunition. This may be accomplished by placing the taggant between the primer and the propellant. When the ammunition is fired, the primer chemicals produce hot reaction

products which normally mix with and ignite the propellant. If the taggant is in a layer between the primer and the propellant, it will be fragmented, and/or vaporized by the expansion of the hot primer product vapor. The taggant fragments and/or vapor will be entrained in the expanding gases from the primer, and will be mixed with the propellant as it is ignited. By this method, the taggant will be well dispersed in the gunshot residue.

To eliminate any remaining concern about possible sensitization of either the primer or the propellant by the taggant, the taggant can be isolated from both by having it sandwiched between two layers of materials known to be compatible with primer and propellant exposure, respectively. These layers would be of a predetermined thickness sufficient to ensure that the taggant remains isolated from both the primer and the propellant until the ammunition is fired. The isolating layers can be made of any material which is easily shredded, vaporized, burned, or otherwise destroyed by the expanding vapor plume of primer reaction products. Examples of possible barrier materials include paper, wax, and certain plastics. Other materials useful for this application are considered to be equivalents. Figure 1 is a diagram of a primer showing how this system could be applied. The primer cup **10** contains the primer reactants **12**, over which is deposited a protective layer **14**, a taggant layer **16**, and an additional protective layer **18**.

The following is a specific embodiment of this system. In manufacturing a round of .38 caliber handgun ammunition, a primer is fabricated using a brass cup containing approximately 15 mg of primer chemicals. Over this is deposited a thin layer of wax, an additional layer containing approximately 15 ng of europium with the isotopes ^{151}Eu and ^{153}Eu in the ratio 25/75, and a final thin layer of wax. The primer is inserted into an empty brass case, to which is added approximately 200 mg of gunpowder propellant, and a projectile. When the round of ammunition has been fully assembled as described, neither the primer nor the propellant is exposed to the europium taggant.

When this round of ammunition is fired, the hot expanding vapors from the reaction of the primer chemicals will shred and vaporize the wax layers. The europium will be entrained in the primer vapor and will mix with the propellant as it is ignited. The europium will be oxidized, forming europium oxide, which will condense and mix with the gunshot residue. Since the europium was present initially at one part per million of the primer mass, any residue particle formed of primer material will contain at least 1 ppm of europium. Since the chemical reactions involved will not significantly alter the isotopic abundance ratio, the europium in the gunshot residue particles will have the same isotopic composition as the original taggant. A typical residue particle might have a mass of 3×10^{-10} g, and will contain at least 3×10^{-16} g of europium. This is about 1.2 million atoms. Measurement of the isotopic composition of the europium in this particle is possible using various mass spectrometric techniques. The number of atoms present is sufficient to ensure a statistically significant reading of the abundance ratio to better than 1% precision. Reading of this ratio will yield the original tagging isotopic composition, and therefore the serial number of the ammunition batch.

An alternative to the wax encapsulated taggant would be to use a pellet insert. The pellet would be fabricated from a material, such as paper, which is easily destroyed by the chemical reaction of the primer or propellant. For example, a small disk of paper would be wetted with a volatile solvent containing a non-volatile taggant. The solvent would be allowed to evaporate, leaving the taggant in the paper. The dry paper disk would then be inserted into the primer cartridge. This is illustrated in Figure 1, where taggant-containing pellets **20** are shown embedded within the primer reactants. Alternatively, the pellets **22** are attached to the surface of the primer reactants. When the ammunition is fired, the pellet would be destroyed and the taggant would be entrained by the primer vapors, mix with the igniting propellant, and ultimately condense in the gunshot residue. Such paper taggants could also simply be inserted in the

cartridge case along with the propellant. This is illustrated in Figure 2 where the cartridge case **30** contains propellant **32** and a projectile **34**. The taggant pellets **36** are distributed throughout the propellant. Alternatively, the taggant pellets **38** can be added after the propellant, and remain between the propellant and the projectile. The paper would be destroyed in firing the ammunition and the taggants would be dispersed.

In the pellet system, the taggant would be dispersed throughout the pellet, which acts as a carrier. Alternatively, the taggant may be completely enclosed in a small capsule made of a material easily destroyed in firing the ammunition. This will further ensure that the taggant is completely isolated from the propellant or primer reactants. The taggant capsules could be deployed in the ammunition in the same manner as the pellets described above.

To reduce the risk of tampering, the taggant may be deposited such that it is covered by the primer reactants. The taggant may be deposited in the primer case prior to loading the primer reactants. This is illustrated in Figure 1, where a taggant layer **24** is covered by a protective layer **26**, and further covered by the primer reactants **12**. If the taggant is easily vaporized, and is covered by a protective layer which is also easily vaporized, the firing of the ammunition would result in the taggant vapor being mixed with the primer vapor as it is expelled into, and ignites, the propellants. The taggant will thus be incorporated in the gunshot residue as it condenses.

If it is desired to tag the ammunition without tagging the primer, one could deposit the taggant on the inner wall of the cartridge case, and cover it with a layer of material to isolate it from the propellant. When the ammunition is fired, the covering layer and the taggant will be vaporized, entrained in the burning propellant, and ultimately deposited with the gunshot residue.

Were ammunition manufactured on an assembly line, with all the components moving sequentially through the various processing steps into the final packaging for shipment, it would be straight-forward to maintain a clear correspondence between position on the assembly line and

the serial number of the ammunition round. This would be very useful for any system incorporating taggants in the primer, since primers are normally manufactured early in the process.

Current manufacturing processes, however, typically have the primers being fabricated in batches, which are then installed in cartridge cases in such a way that it would be difficult to keep track of the taggant serial number for any given round of ammunition.

A process which would eliminate this issue would be to print a small unique machine-readable label, such as a barcode, on each primer. A record is maintained of the correspondence between the barcode and the taggant code. As each round of ammunition is boxed for final shipment, the barcode of each primer is read, and a record is maintained of each taggant code in any given box of ammunition.

It is understood that the above-described preferred embodiments and examples are simply illustrative of the general principles of the present invention. Other formulations, arrangements, assemblies and materials may be used by those skilled in this art and which embody the principles of the present invention, which is limited only by the scope and spirit of the claims set forth below.

What is claimed is:

1. Tagged ammunition comprising:

a projectile;

a cartridge case;

a propellant;

a primer including primer reactants; and

a taggant contained in the primer.

2. The tagged ammunition of claim 1 wherein the taggant is an ingredient in a mixture that includes the primer reactants.

3. The tagged ammunition of claim 1 wherein the taggant is positioned on the surface of the primer reactants.

4. The tagged ammunition of claim 3 further including a material of predetermined thickness positioned between the primer reactants and the taggant.

5. The tagged ammunition of claim 3 further including a material of predetermined thickness positioned between the propellant and the taggant.

6. The tagged ammunition of claim 4 further including a material of predetermined thickness positioned between the propellant and the taggant.

7. Tagged ammunition comprising:

a projectile;

a cartridge case;

a propellant;

a primer having a primer case and primer reactants; and

a taggant on the surface of the primer case.

8. The tagged ammunition of claim 7 further including a material of predetermined thickness positioned between the primer reactants and the taggant.

9. Tagged ammunition comprising:

a projectile;

a cartridge case;

a propellant;

a primer;

a capsule made of a material capable of being destroyed during firing of the ammunition; and

a taggant positioned within the capsule.

10. The tagged ammunition of claim 9 wherein the capsule is positioned within the cartridge case.

11. The tagged ammunition of claim 9 wherein the capsule is positioned in the primer.

12. Tagged ammunition comprising:

a projectile;

a cartridge case;

a propellant;

a primer;

a pellet made of a material capable of being destroyed during firing of the ammunition; and

a taggant positioned within the pellet.

13. The tagged ammunition of claim 12 wherein the pellet is positioned within the cartridge case.

14. The tagged ammunition of claim 12 wherein the pellet is positioned in the primer.

Method of Tagging Ammunition

15. A method of tagging ammunition having a projectile, a primer, and a propellant comprising:

selecting a taggant; and

incorporating the taggant within the primer.

16. A method of tagging ammunition having a projectile, a propellant, and a primer including primer reactants comprising:

selecting a taggant; and

mixing the taggant with the primer reactants.

17. A method of tagging ammunition having a projectile, a propellant, and a primer including primer reactants comprising:

selecting a taggant; and

depositing the taggant on the surface of the primer reactants.

18. The method of claim 17 further including:

depositing a layer of material of predetermined thickness between the primer reactants and the taggant.

19. The method of claim 17 further including:

depositing a layer of material of predetermined thickness between the propellant and the taggant.

20. The method of claim 19 further including:

depositing a layer of material of predetermined thickness between the primer reactants and the taggant.

21. A method of tagging ammunition having a cartridge case, a projectile, a propellant, and a primer comprising:

selecting a taggant; and

depositing the taggant in a layer in the cartridge case.

22. The method of claim 21 further including:

depositing a layer of material of predetermined thickness between the cartridge case and the primer reactants.

23. A method of tagging ammunition having a cartridge case, a projectile, a propellant, and a primer including primer case and primer reactants comprising:

selecting a taggant; and

depositing the taggant in a layer in the primer case; and

depositing the primer reactants in the primer case so as to cover the taggant.

24. The method of claim 23 further including:

depositing a layer of material of predetermined thickness between the primer case and the primer reactants.

25. A method of tagging ammunition having a cartridge case, a projectile, a propellant, and a primer comprising:

selecting a taggant; and

depositing the taggant within a capsule made of a material easily destroyed during firing of the ammunition; and

depositing said capsule in the cartridge case.

26. A method of tagging ammunition having a cartridge case, a projectile, a propellant, and a primer comprising:

selecting a taggant; and

depositing the taggant within a capsule made of a material easily destroyed during firing of the ammunition; and

depositing said capsule in the primer.

27. A method of tagging ammunition having a cartridge case, a projectile, a propellant, and a primer comprising:

selecting a taggant; and

depositing the taggant within a pellet made of a material easily destroyed during firing of the ammunition; and

depositing said pellet in the cartridge case.

28. A method of tagging ammunition having a cartridge case, a projectile, a propellant, and a primer comprising:

selecting a taggant; and

depositing the taggant within a pellet made of a material easily destroyed during firing of the ammunition; and

depositing said pellet in the primer.

Fragmented Particulate Taggants

29. A particulate taggant for identifying a predetermined, encoded serial number comprising:

a first type of particle encoding a first portion of said serial number comprising:

a first code, representative of said first portion of the encoded serial number; and

a second code, identifying a particle to be one of the first type; and

a second type of particle encoding a second portion of said serial number comprising:

a third code, representative of a second portion of the encoded serial number; and

a fourth code, identifying a particle to be one of the second type.

30. The taggant of claim 29 further including:

a third type of particle encoding a third portion of said serial number comprising:

a fifth code, representative of a third portion of the encoded serial number; and

a sixth code, identifying a particle to be one of the third type.

31. The taggant of claim 29 further including:

multiple additional types of particles, each additional type of particle encoding one additional portion of said serial number, and each additional type of particle comprising:

a code, representative of said additional portion of the encoded serial number; and

a code, identifying a particle to be of the type encoding said additional portion of the encoded serial number.

Methods of Tagging Using Fragmented Particulate Taggants

32. A method of tagging comprising:

selecting a serial number;

selecting a first portion of said serial number;

selecting a second portion of said serial number;

providing a plurality of first type of taggant particles;

each of said first type of taggant particles containing a code indicative of the value of the first portion of said serial number; and

each of said first type of taggant particles containing a code identifying the particle to be one of the first type; and

providing a plurality of second type of taggant particles;

each of said second type of taggant particles containing a code indicative of the value of the second portion of said serial number; and

each of said second type of taggant particles containing a code identifying the particle to be one of the second type.

33. The method of claim 32 further comprising:

providing a plurality of a third type of taggant particles;

each of said third type of taggant particles containing a code indicative of the value of a third portion of said serial number; and

each of said third type of taggant particles containing a code identifying the particle to be one of the third type.

34. The method of claim 32 further comprising:

providing multiple additional types of taggant particles;

each particle of each additional type of particles containing a code indicative of the value of a predesignated additional portion of said serial number; and

each particle of each additional type of particles containing a code identifying the particle to be of the type encoding said predesignated additional portion of the encoded serial number.

Methods of Encoding Distributed Taggants

35. A method of encoding chemical taggants using multiple pairs of chemicals to represent the bits of a binary serial number wherein the presence of one chemical of each pair represents a first predetermined bit value and the presence of the other chemical of each pair represents a second predetermined bit value.

36. The method of claim 35 where one of the predetermined bit values is 0 and the other predetermined bit value is 1.

37. A method of encoding chemical taggants comprising:

identifying a group of M × N distinct chemical taggants where M and N are integers; and

dividing said chemical taggants into M groups of N chemicals each; and

assigning one taggant chemical from each of the M groups to correspond to each integer from 0 to N-1 inclusive; and

isolating the substance to be tagged and assigning to it an M-digit, base-N serial number; and

adding to the substance to be tagged a quantity of each of the M chemicals corresponding to the values of the M digits in the assigned serial number.

38. The method of claim 37 where at least one of the taggant chemicals is isotopically substituted.

39. A method of encoding isotopic taggants using multiple pairs of isotopes to represent the bits of a binary serial number wherein the presence of one isotope of each pair represents a first

predetermined bit value and the presence of the other isotope of each pair represents a second predetermined bit value.

40. The method of claim 39 where one of the predetermined bit values is 0 and the other predetermined bit value is 1.

41. A method of encoding isotopic taggants comprising:

identifying a group of M × N distinct isotopic taggants where M and N are integers; and

dividing said isotopic taggants into M groups of N isotopes each; and

assigning one taggant isotope from each of the M groups to correspond to each integer from 0 to N-1 inclusive; and

isolating the substance to be tagged and assigning to it an M-digit, base-N serial number; and

adding to the substance to be tagged a quantity of each of the M isotopes corresponding to the values of the M digits in the assigned serial number.

Base-N Taggants

42. A binary taggant comprising:

at least a first chemical pair comprising:

a first chemical of the first chemical pair capable of functioning as a taggant and representative of the first of two binary values; and

a second chemical of the first chemical pair capable of functioning as a taggant and representative of the second of the two binary values.

43. The binary taggant of claim 42 further comprising:

a second chemical pair comprising:

a first chemical of the second chemical pair capable of functioning as a taggant and representative of the first of two binary values; and

a second chemical of the second chemical pair capable of functioning as a taggant and representative of the second of the two binary values.

44. The binary taggant of claim 42 further comprising:

at least two additional chemical pairs each of said pairs comprising:

a first chemical of each additional chemical pair capable of functioning as a taggant and representative of the first of two binary values; and

a second chemical of each additional chemical pair capable of functioning as a taggant and representative of the second of the two binary values.

45. A binary taggant comprising:

at least a first isotope pair comprising:

a first isotope of the first isotope pair capable of functioning as a taggant and representative of the first of two binary values; and

a second isotope of the first isotope pair capable of functioning as a taggant and representative of the second of the two binary values.

46. The binary taggant of claim 45 further comprising:

a second isotope pair comprising:

a first isotope of the second isotope pair capable of functioning as a taggant and representative of the first of two binary values; and

a second isotope of the second isotope pair capable of functioning as a taggant and representative of the second of the two binary values.

47. The binary taggant of claim 45 further comprising:

at least two additional isotope pairs each of said pairs comprising:

a first isotope of each additional isotope pair capable of functioning as a taggant and representative of the first of two binary values; and

a second isotope of each additional isotope pair capable of functioning as a taggant and representative of the second of the two binary values.

48. An encoded taggant system capable of representing any M-digit, base-N serial number where M and N are integers, comprising:

M x N distinct chemicals each capable of functioning as a taggant;

said M x N distinct chemicals grouped into M groups of N distinct chemicals in each of the M groups; and

each of the N distinct chemical in each of the M groups corresponding to one integer from 0 to N-1 inclusive,

whereby a quantity of the distinct chemicals corresponding to the values of a predetermined, M-digit, base-N serial number may be selected and added to a substance assigned to the predetermined serial number.

49. The taggant system of claim 48 wherein at least one of the taggant chemicals is isotopically substituted.

Methods of Ensuring Authentication For Taggants

50. A method of ensuring the authenticity of an identification taggant comprising:

selecting a first taggant representative of identification information;

selecting a second taggant representative of an authentication code; and

combining the first and second taggants to form an authenticated taggant.

51. The method of claim 50 wherein the first taggant is selected from the group consisting essentially of particulate, chemical, or isotopic taggants and

the second taggant is selected from the group consisting essentially of another one of either particulate, chemical or isotopic taggants.

52. The method of claim 50 wherein the first taggant is a fragmented particulate taggant, and the second taggant is an isotopic taggant.

53. The method of claim 52 where the said identification information is selected from one or more of the identity of the manufacturer, type of ammunition, date of manufacture, and/or place of manufacture.

Authenticated Taggants

54. A taggant composition comprising:

a first taggant encoding identifying information; and

a second taggant encoding an authentication code.

55. The taggant composition of claim 54 where the first taggant is selected from the group consisting essentially of particulate, chemical, or isotopic taggants, and

the second taggant is selected from the group consisting essentially of another one of either particulate, chemical or isotopic taggants.

56. A taggant composition comprising:

a particulate taggant; and

a distributed taggant.

57. The taggant composition of claim 56 wherein the distributed taggant is:

a distributed chemical taggant.

58. The taggant composition of claim 56 wherein the distributed taggant is:

a distributed isotopic taggant.

Labeled Taggant System and Method

59. A method of tagging ammunition having a projectile, a cartridge, and a primer comprising:

printing a label on the primer such that it is readable after the ammunition is fully assembled; and

selecting a taggant; and

depositing the taggant in the primer.

60. Tagged ammunition comprising:

a projectile;

a cartridge case;

a primer;

a taggant positioned within the primer; and

a label on the primer visible when the ammunition is fully assembled.

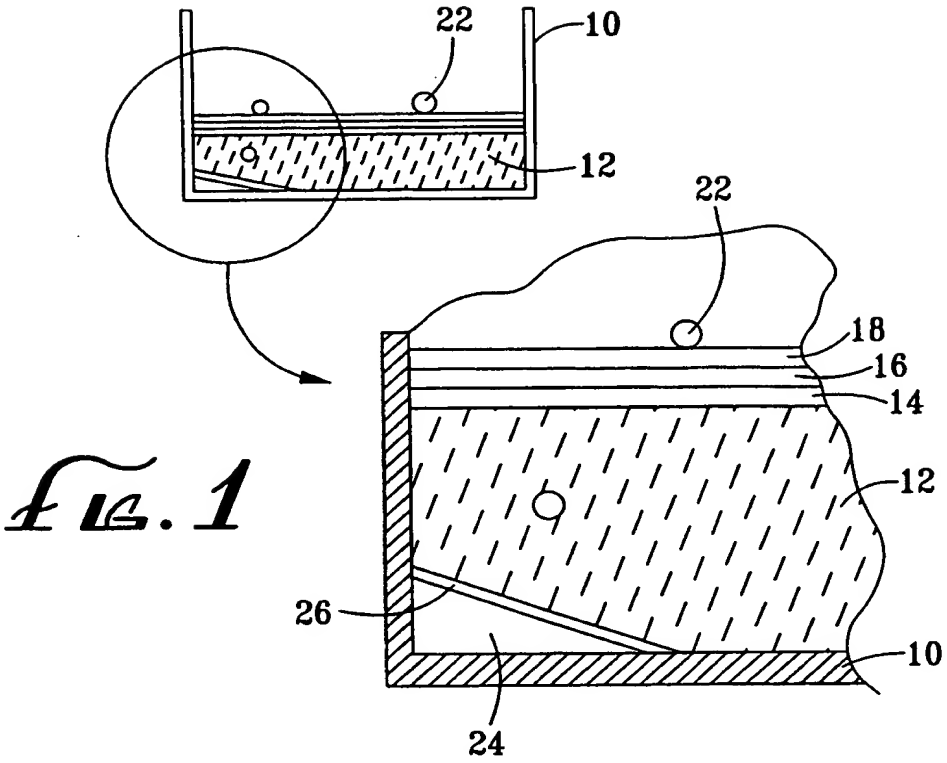


FIG. 1

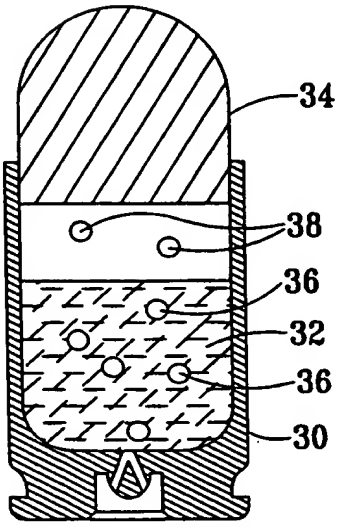


FIG. 2

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(74) Agents: HOKANSON, Jon, E. et al.; Small Larkin, LLP, 18th Floor, 10940 Wilshire Boulevard, Los Angeles, CA 90024 (US).

(81) Designated States *(national)*: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

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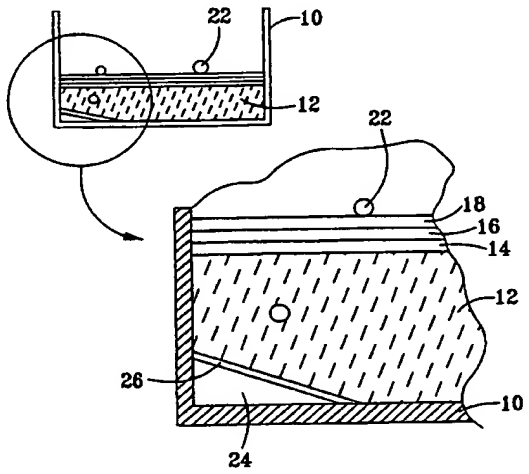
— *With international search report.*

(88) Date of publication of the international search report:
19 April 2001

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: FRAGMENTED TAGGANT AMMUNITION CODING SYSTEM AND METHOD



(57) Abstract: The present invention relates to identification tagging and is specifically directed to identification tagging of ammunition (10). An isotopic taggant (16) is deposited in a layer at the interface between the primer (12) and the propellant so that, as the ammunition is fired, the taggant is dispersed throughout the propellant. The taggant is thus contained in the gunshot residue formed during the firing, and can be read by analysis of residue particles. Alternatively, the taggant may be deposited in a layer (24) under the primer reactants, or in pellets (22) which are easily destroyed by the chemical reactions involved in firing the ammunition, again dispersing the taggant throughout the propellant and the gunshot residue. Non-isotopic chemical taggants may also be employed if they are encoded so as to minimize the possibility of the information being destroyed or improperly read after the taggants are exposed to the chemical reactions in firing the ammunition. This is accomplished by employing a binary coding system and a system of authentication tags. Particulate taggants may also be used. The required large number of unique identification tags are obtained by using a fragmented coding system wherein each particle encodes only a portion of the serial number.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/13937

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) :F42B 5/02
US CL :102/430
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 102/204, 430; 149/123

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US, 4,222,330 A (KRYSTYNIAK) 16 SEPTEMBER 1980 (16/09/80), SEE ENTIRE DOCUMENT.	1, 2, 15, 16 ----- 59, 60
Y, E	US 6,082,264 A (MEYER ET AL) 04 JULY 2000 (04/07/00), SEE FIG. 5 AND LINES 34-46 OF COL. 6.	59, 60
Y	WO 97/21067 A (BEUKES ET AL) 12 JUNE 1997 (12/06/97), SEE FIG. 2 AND LINES 29-32 OF PAGE 9.	59, 60
A	US 1,650,908 A (RAMSEY) 29 NOVEMBER 1927 (29/11/27)	
A	US 3,772,200 A (LIVESAY) 13 NOVEMBER 1973 (13/11/73)	

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 31 OCTOBER 2000	Date of mailing of the international search report 09 JAN 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer HAROLD TUDOR Telephone No. (703) 306-4172

Form PCT/ISA/210 (second sheet) (July 1998)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/13937

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,018,635 A (RYAN ET AL) 19 APRIL 1977 (19/04/77)	
A	US 4,131,064 A (RYAN ET AL) 26 DECEMBER 1978 (26/12/78)	
A	US 4,329,393 A (LA PERRE ET AL) 11 MAY 1982 (11/05/82)	
A	US 4,359,353 A (KYDD) 16 NOVEMBER 1982 (16/11/82)	
A	US 4,359,399 A (BOYARS) 16 NOVEMBER 1982 (16/11/82)	
A	US 4,363,678 A (NISHIMURA ET AL) 14 DECEMBER 1982	
A	US 4,399,226 A (DANIELSON ET AL) 16 AUGUST 1983 (10/08/83)	
A	US 4,455,179 A (YAMAGUCHI ET AL) 19 JUNE 1984 (19/06/84)	
A	US 5,646,365 A (COLLIER) 08 JULY 1997 (08/07/97)	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/13937

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1, 2, 15, 16, 59, 60

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/13937

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

Group I, tagged ammunition and method of tagging ammunition wherein the taggant is an ingredient of a primer mixture, claims 1, 2, 15, 16, 59 and 60.
Group II, tagged ammunition and method of tagging ammunition wherein the taggant is on a surface of the primer, claims 1, 3-6, 15, 17-20, 59 and 60.
Group III, tagged ammunition and method of tagging ammunition wherein the taggant is in a sapsule, claims 1, 9-11, 15, 25, 26, 59 and 60.
Group IV, tagged ammunition and method of tagging ammunition wherein the taggant is in a pellet, claims 1, 12-14, 15, 27, 28, 59 and 60.
Group V, tagged ammunition and method of tagging ammunition wherein the taggant is on the surface of the primer case, claims 1, 7, 8, 15, 59 and 60.
Group VI, a method of tagging ammunition wherein the taggant is in a layer in a cartridge case, claims 21 and 22.
Group VII, tagged ammunition and method of tagging ammunition wherein the taggant is in a layer in a primer case, claims 1, 15, 23, 24, 59 and 60.
Group VIII, taggant and method of tagging wherein the taggant is a particulate, claims 29-34, and 50-56.
Group IX, taggant and method of tagging wherein the taggant is a chemical, claims 35-37, 42-44, 48-51, 54 and 55.
Group X, taggant and method of tagging wherein the taggant is an isotope, claims 39-41, 45-47, 50-55.
Group XI, method of tagging comtaining a chemical taggant and an isotopic taggant, claim 38.
Group XII, a taggant comprising a particulate taggant and a chemical taggant, claims 56 and 57.
Group XIII, a taggant comprising a particulate taggant and an isotopic taggant, claims 56 and 58.